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PHYSIOLOGIC RESPONSE TO SUBGRAVITY. MECHANICS OF NOURISHMENT AN--ETC(U)
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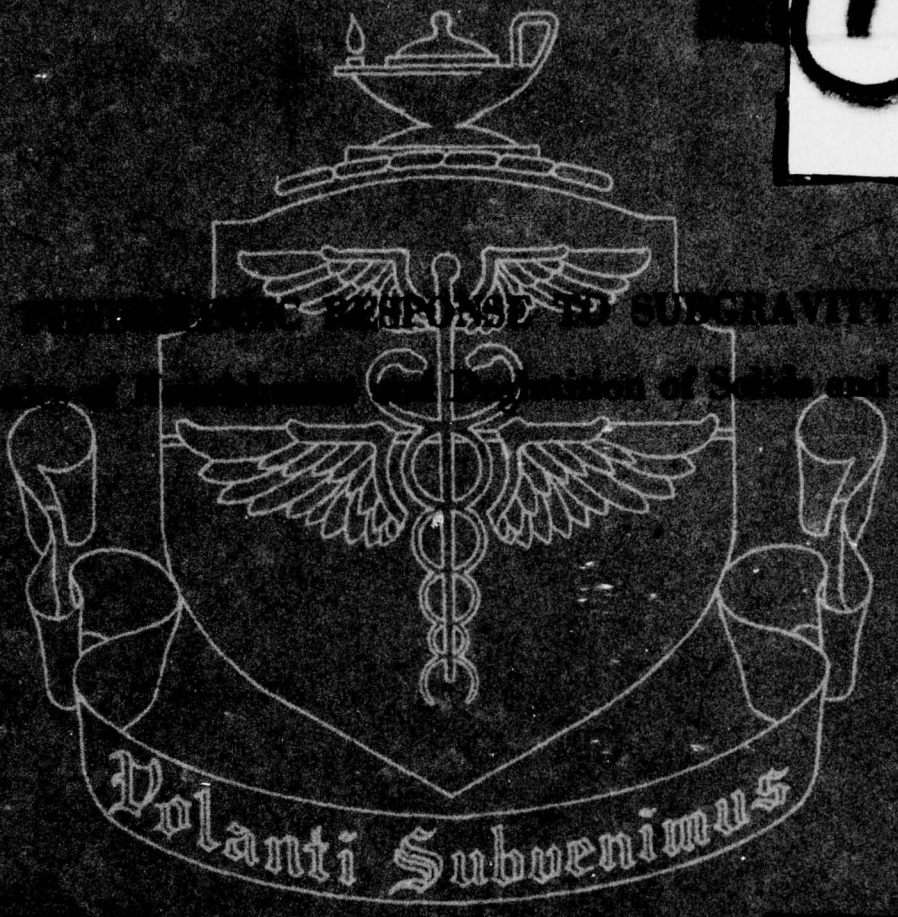

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PHYSIOLOGIC RESPONSE TO SUBGRAVITY,

Mechanics of Nourishment and Deglutition of Solids and Liquids

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PHYSIOLOGIC RESPONSE TO SUBGRAVITY

Mechanics of Nourishment and Deglutition of Solids and Liquids

In order to study the mechanics of nourishment during weightlessness, 165 subgravity parabolas were flown in an F-94C aircraft. Twenty-five experimental subjects attempted to drink from an open container, a container fitted with pierced lid and plastic straw, and a plastic squeeze bottle. Observations were made regarding deglutition of solids, including swallowing of both well and poorly masticated boli. Drinking from open containers proved to be more difficult than had been anticipated. For reasons of safety, closed containers, such as squeeze bottles, must be used to transfer liquids to the mouth under conditions of zero-gravity; the use of straws is not practical. Deglutition of liquids or well masticated solids can be accomplished with little or no difficulty in the weightless state. However, a large solid bolus of food is a potential aspiration problem. Regurgitation of stomach contents may become a serious annoyance during orbital flight. Only a small quantity of liquids should be taken at one time. Movements or abdominal pressures, which may initiate vomiting, must be avoided.

The imminent reality of manned extra-atmospheric circumterrestrial flight grows increasingly apparent. Such flights may be considered space equivalent in terms of the motion characteristics of the space vehicle. Relatively prolonged periods of subgravity and zero-gravity may be anticipated although distance from the earth's surface may be only a few hundred miles.

The relationship between the accelerative field within the cabin of the vehicle and the state of nutrition of the occupants may be expected to become significant during prolonged flights of many hours or days. The extensive investigations by Hoelzel (3) of the correlation between the specific gravity of foodstuffs and the rapidity of their passage through the gastrointestinal tract of men and animals appear to indicate that within the limits of ordinary foods, specific gravity per se is not of prime importance in regulating intestinal motility. These studies show that the time required for food passage decreases with materials of low specific gravity. Therefore, the absence of food weight alone apparently does not constitute the source of passage rate problems. Food bulk, however, is an extremely important factor in preventing constipation.

Certain facets of the mechanics of nourishment, including deglutition and manual conveyance of liquids and solids to the mouth, were deemed appropriate areas for investigation. Many authors have given cursory consideration to the possibility of problems arising from attempts to eat and drink in a reduced gravitational field. An amusing and scientific treatment was given this subject in the Walt Disney color cartoon *Man in Space*. In this film, particular emphasis was placed on the inconvenience anticipated in drinking from an open container.

METHOD

Subjects of the experiment were 25 volunteers, diverse as to background, age, and flying experience. Weightlessness for periods of 35 to 40 seconds was produced in an F-94C *Starfire* fighter-type aircraft (1, 4). In each case the flight plan called for 5 or more parabolas to be flown. Several experimental subjects experienced as many as 30 parabolas during a flight in which eating and drinking observations were made. None of the subjects participated in multiple flights.

A total of 165 parabolas was flown during this experiment. No specific information concerning reactions to be expected was given the subjects prior to the flight. The subjects were asked to record any and all sensations experienced. A knee pad was provided for this purpose. All the subjects were physically fit to fly, at least as jet passengers, as required by

Air Force regulations, and most of them were rated personnel on flying status. Termination of a flight was permitted before the flight plan was completed if severe nausea or vomiting incapacitated the subject. In general, for any particular flight 4 parabolas involved the handling of liquids—including attempts to drink water from an open container, through a straw, and by means of a plastic squeeze bottle.

RESULTS

Because of slight variability of the g field from one flight to another, differences in the subjects' experiences were to be expected. Filmed recordings of many parabolas documented the near-zero-gravity fields obtained. However, in the handling of fluids and in maintaining orientation, it is probably true that "a little g goes a long way."

All subjects, except two, experienced marked difficulty when attempting to drink water from an open container. Although it was realized that such attempts would be exceedingly messy, many of the ramifications had not been anticipated. Even in the process of very slowly lifting the container to face level or tipping it, sufficient upward and rearward acceleration was imparted to the fluid to cause it to leave the container as an amoeboid mass and envelop the face. The fluid flowed into the nasal passages,

FIGURE 1

Subject attempting to drink water from an open container while in the weightless state. The amoeboid mass of water enveloped the face, obstructing the oral and nasal passages.

frequently entering the sinuses as the subjects attempted to breathe. Choking—virtually a sense of drowning—was a common occurrence (fig. 1).

Drinking water with a straw was completely unsatisfactory. It was difficult to keep the straw inserted in water rather than in air bubbles. The lack of weight differential between the air and water permitted both to be sucked into the mouth with equal ease. However, because of the apparent tendency of a water globule to fracture into numerous globules when a straw tip is inserted into it, more air than water was swallowed.

All subjects found the squeeze bottle technic completely satisfactory, and it made no difference whether the water was squirted or sucked into the mouth (fig. 2). Once liquids were conveyed to the mouth by this technic, deglutition was accomplished without difficulty. Nor did subjects have trouble swallowing solids that were masticated into a bolus even slightly liquid. However, a semisolid bolus was swallowed by the subjects with moderate to severe difficulty in over half of the parabolas. A number of subjects reported that pieces of food hung suspended in the oropharynx and several reported that bits of food floated up over the soft palate into the nasal passages.

Several subjects experienced vomiting and nausea, with occurrence in that order. Careful interrogation revealed that regurgitated material

FIGURE 2

By using a plastic squeeze bottle, the subject was able to convey the water into the mouth without difficulty while in the weightless state.

in the mouth caused the subjects to vomit and feel ill. This occurred immediately after ingesting liquids or after application of slight abdominal pressure such as might be caused by the seat belt. It is apparent that utmost precaution will be required of the space traveler to prevent any undue pressure or blow to the abdomen. In addition, the volume of any particular feeding must be kept small. This "weightless regurgitation phenomenon" explains some of the untoward reactions reported from zero-gravity exposures (2).

SUMMARY

1. In order to study the mechanics of nourishment during weightlessness, 165 subgravity parabolas were flown in an F-94C aircraft.

2. Twenty-five experimental subjects attempted to drink from an open container, a container fitted with pierced lid and plastic straw, and a plastic squeeze bottle. Observations were made regarding deglutition of solids, including swallowing of both well and poorly masticated boli.

3. Drinking from open containers proved to be more difficult than had been anticipated. For reasons of safety, closed containers, such as squeeze bottles, must be used to transfer liquids to the mouth under conditions of zero-gravity; the use of straws is not practical.

4. Deglutition of liquids or well masticated solids can be accomplished with little or no difficulty in the weightless state. However, a large solid bolus of food is a potential aspiration problem.

5. Regurgitation of stomach contents may become a serious annoyance during orbital flight. Only a small quantity of liquids should be taken at one time. Movements or abdominal pressures, which may initiate vomiting, must be avoided.

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